Vakantiecursus 2014

Waterwinning zonder verspilling

- Intro
- Textielverven: Een voorbeeld van preventie van waterverbruik
- Waterwinning met produktrecovery

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Sara Salvador (KWR, TU Delft)
Bas Hofs (KWR)

TU Delft

Enkele uitgangspunten

- Theoretisch is zonlicht voldoende om 0.5 m3 zeewater per etmaal per m2 volledig om te zetten naar zuiver zout en water
- Winning of valuable salts at low energy costs.
- Approaching the thermodynamic minimal work for separation

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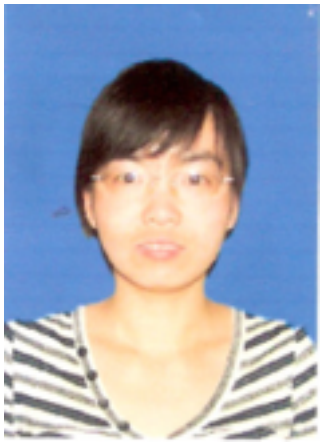
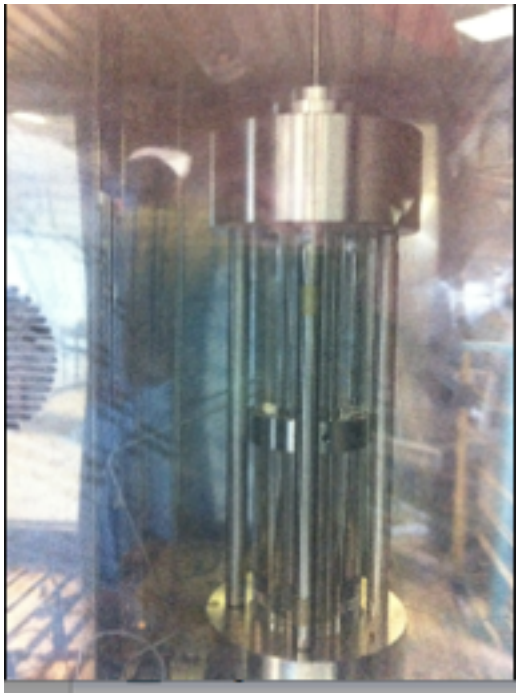
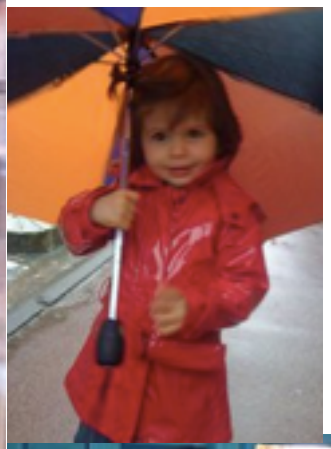
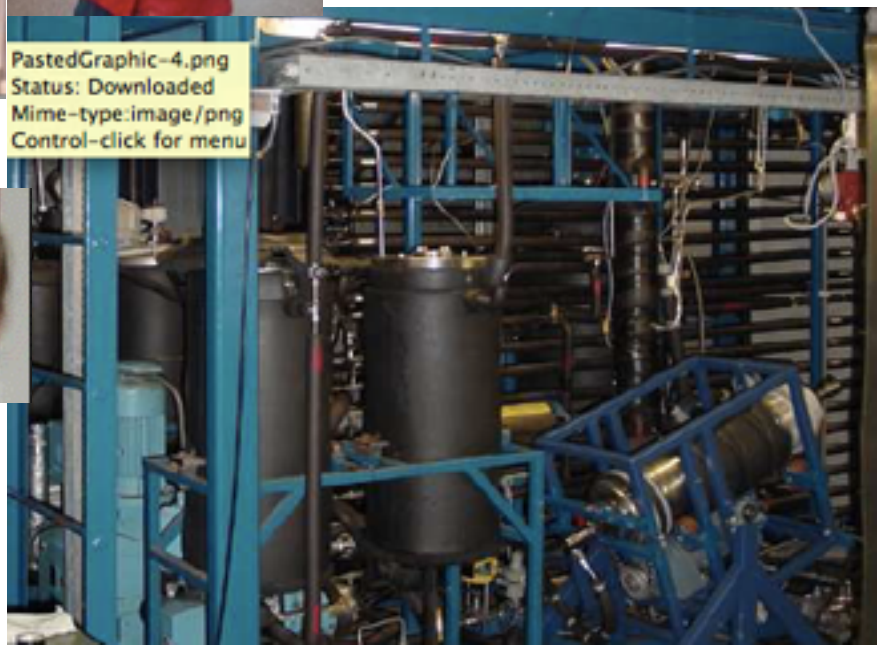
CO2/Ionic liquids

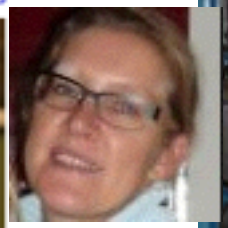




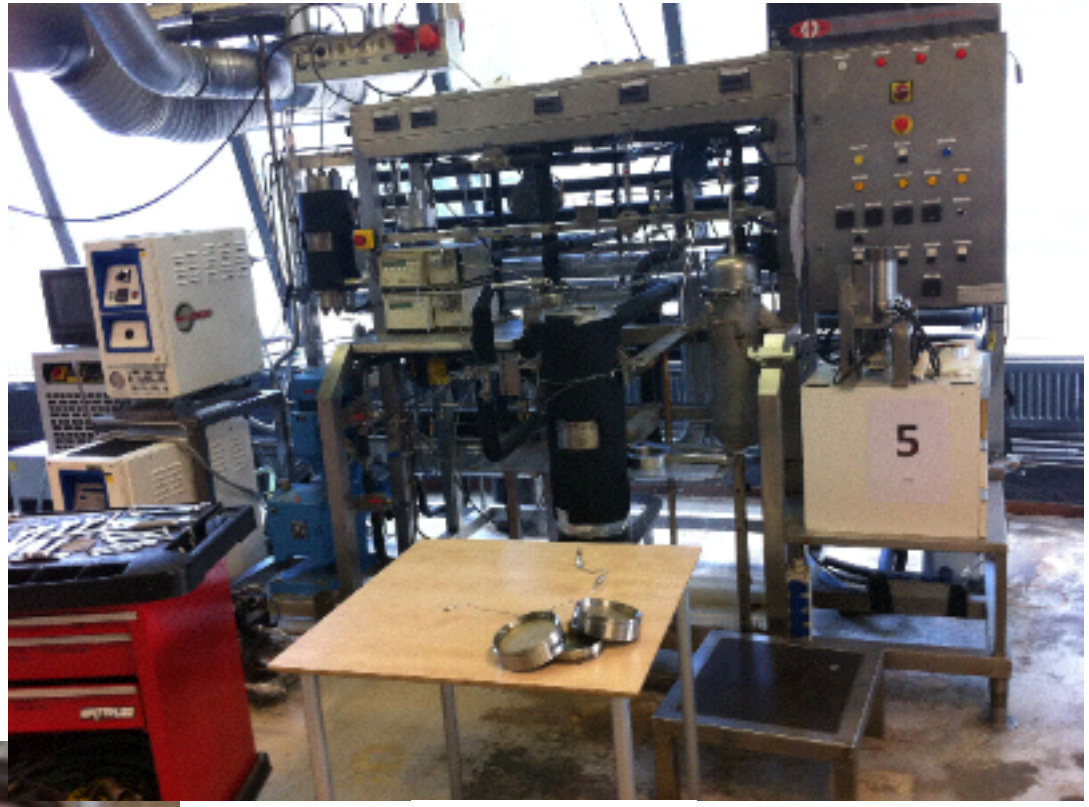
Extraction/separation/misc



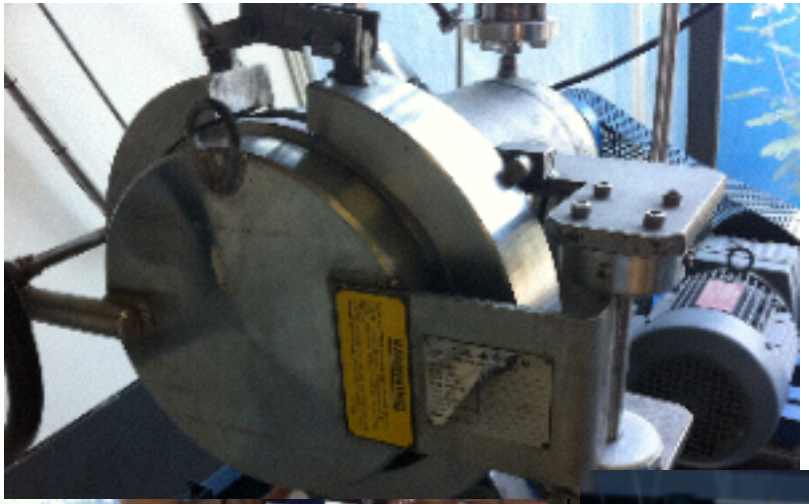




protein precipitation/formulation

- 

Textile dry-cleaning/textile dyeing

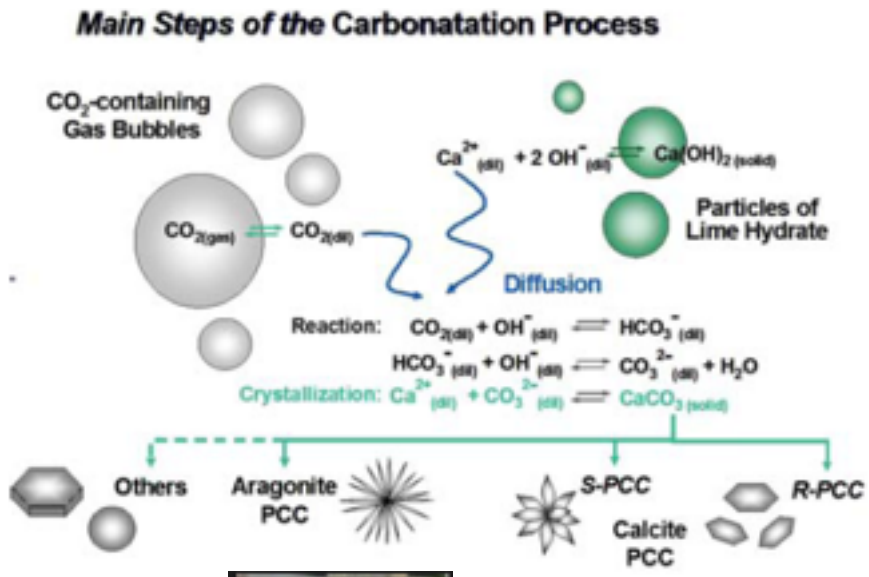


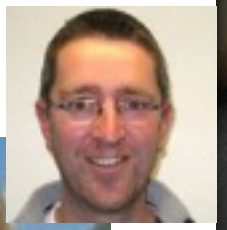
FEBRUARY 07, 2012

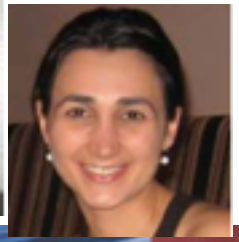
NIKE, INC. ANNOUNCES STRATEGIC PARTNERSHIP TO SCALE WATERLESS DYEING TECHNOLOGY

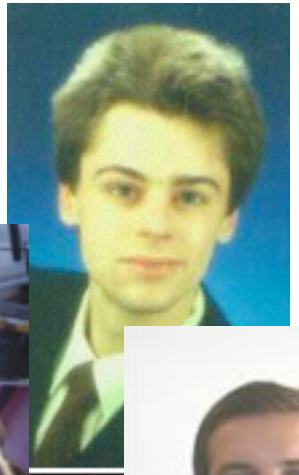
The company has entered into a strategic partnership with DyeCoo Textile Systems B.V., a Netherlands-based company that has developed and built the first commercially available waterless textile dyeing machines.

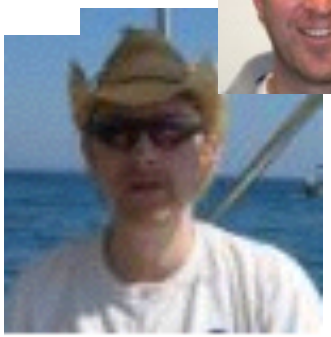
CO2/(eutectic) crystallisation

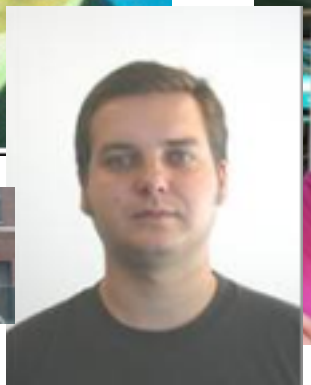


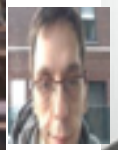












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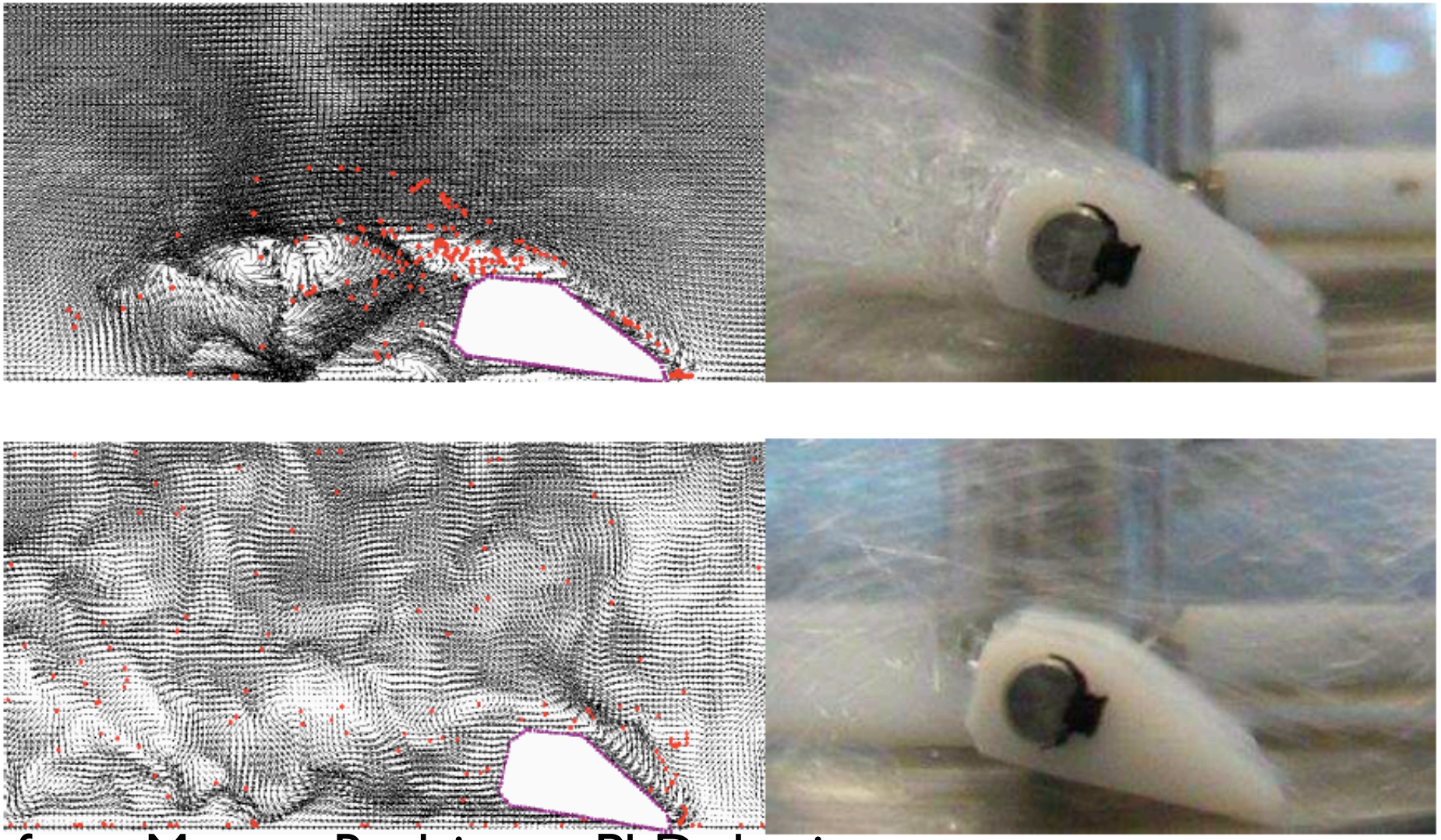
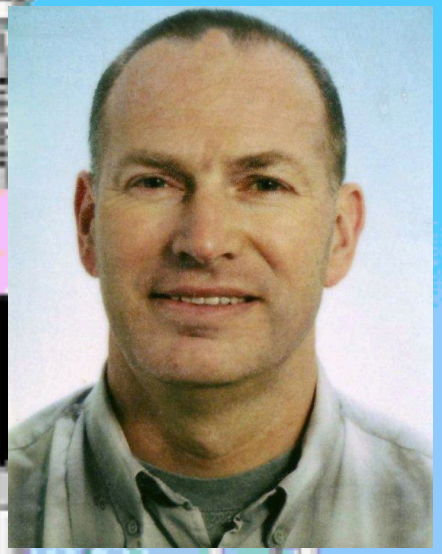
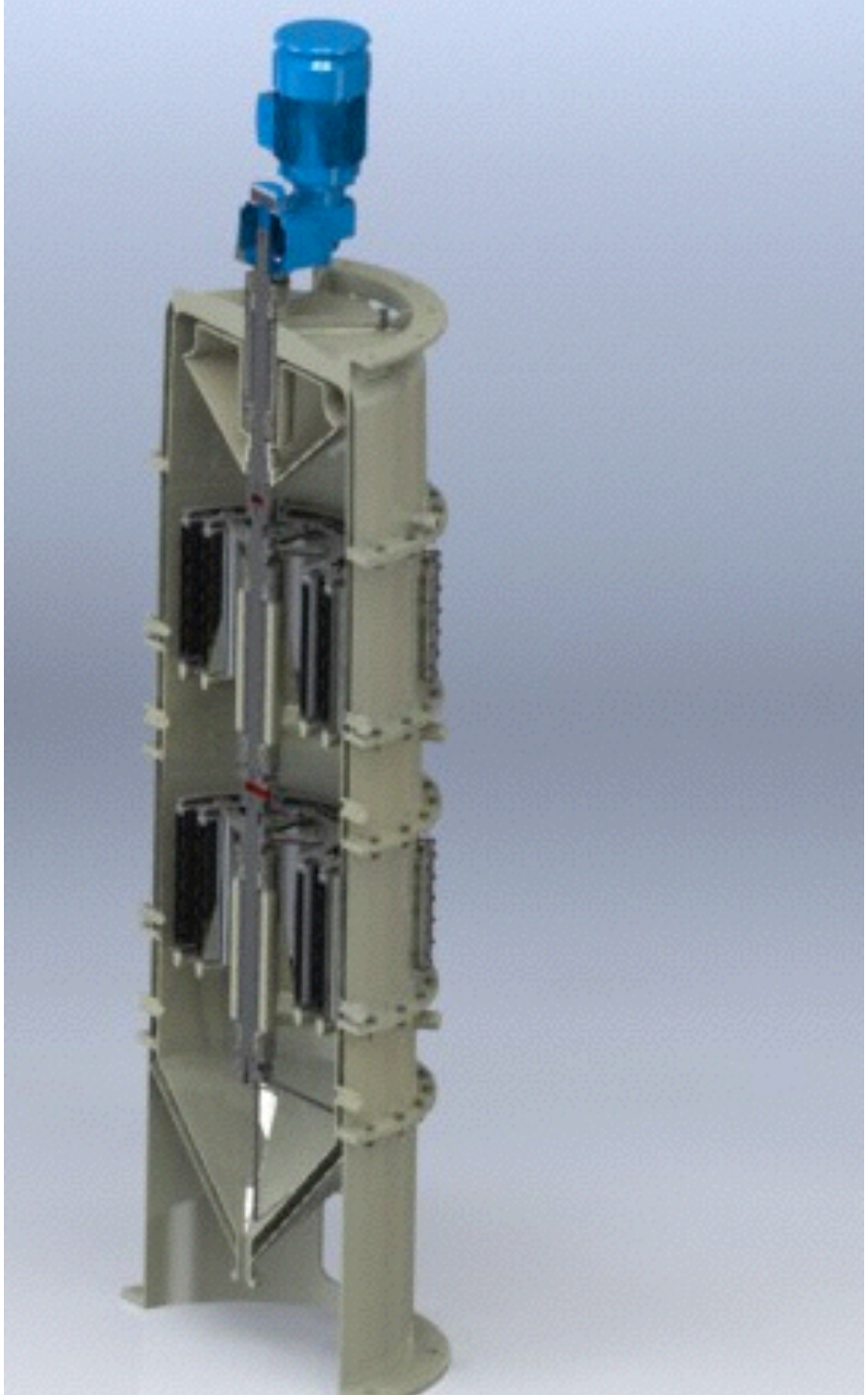


from Marcos Rodriguez, PhD thesis

Figure 6. *Particle trajectories from particle-flow simulations for the streamlined scraper geometry compared to measured particle-flow visualization. The top two figures correspond to 20 seconds after start up, and the bottom two to 230*

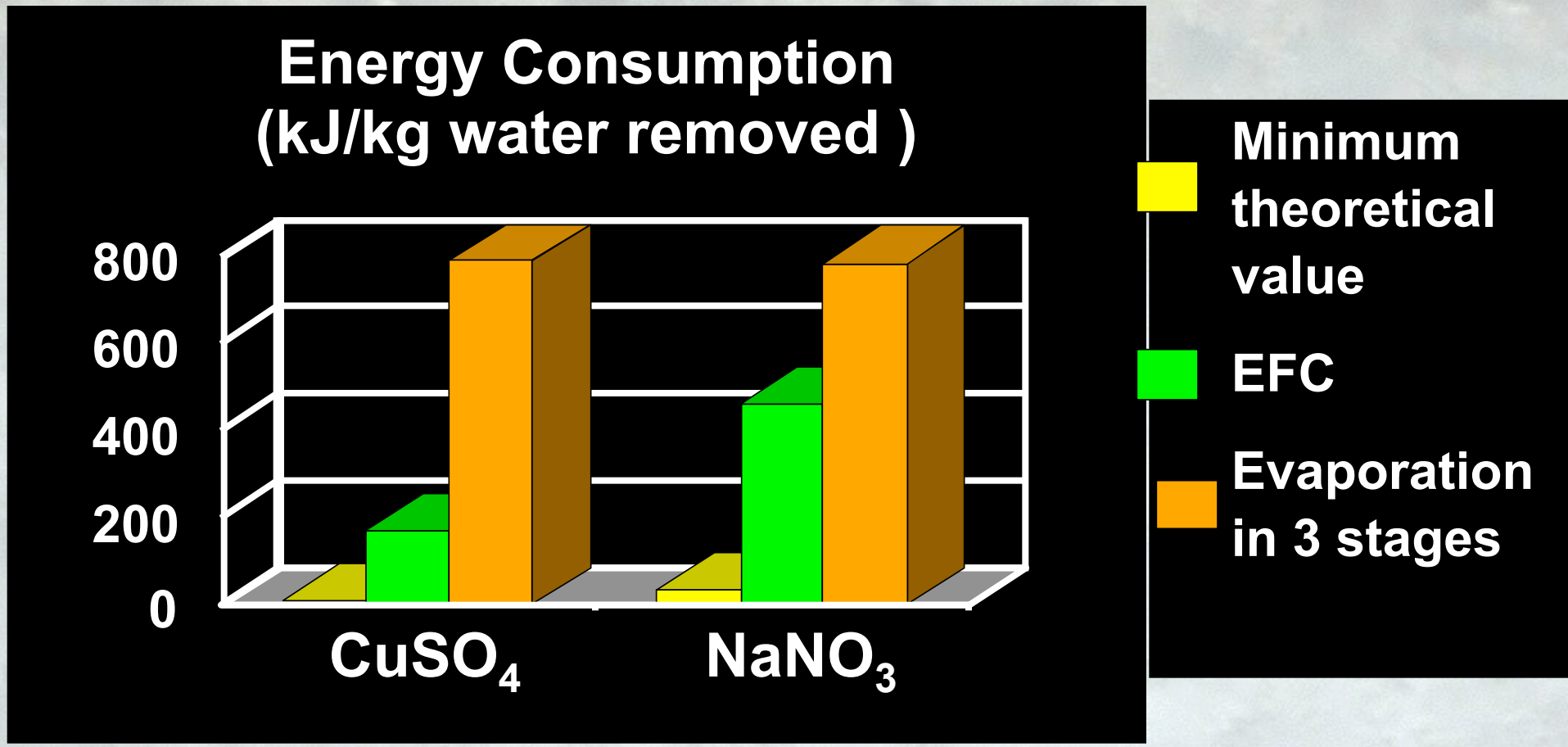




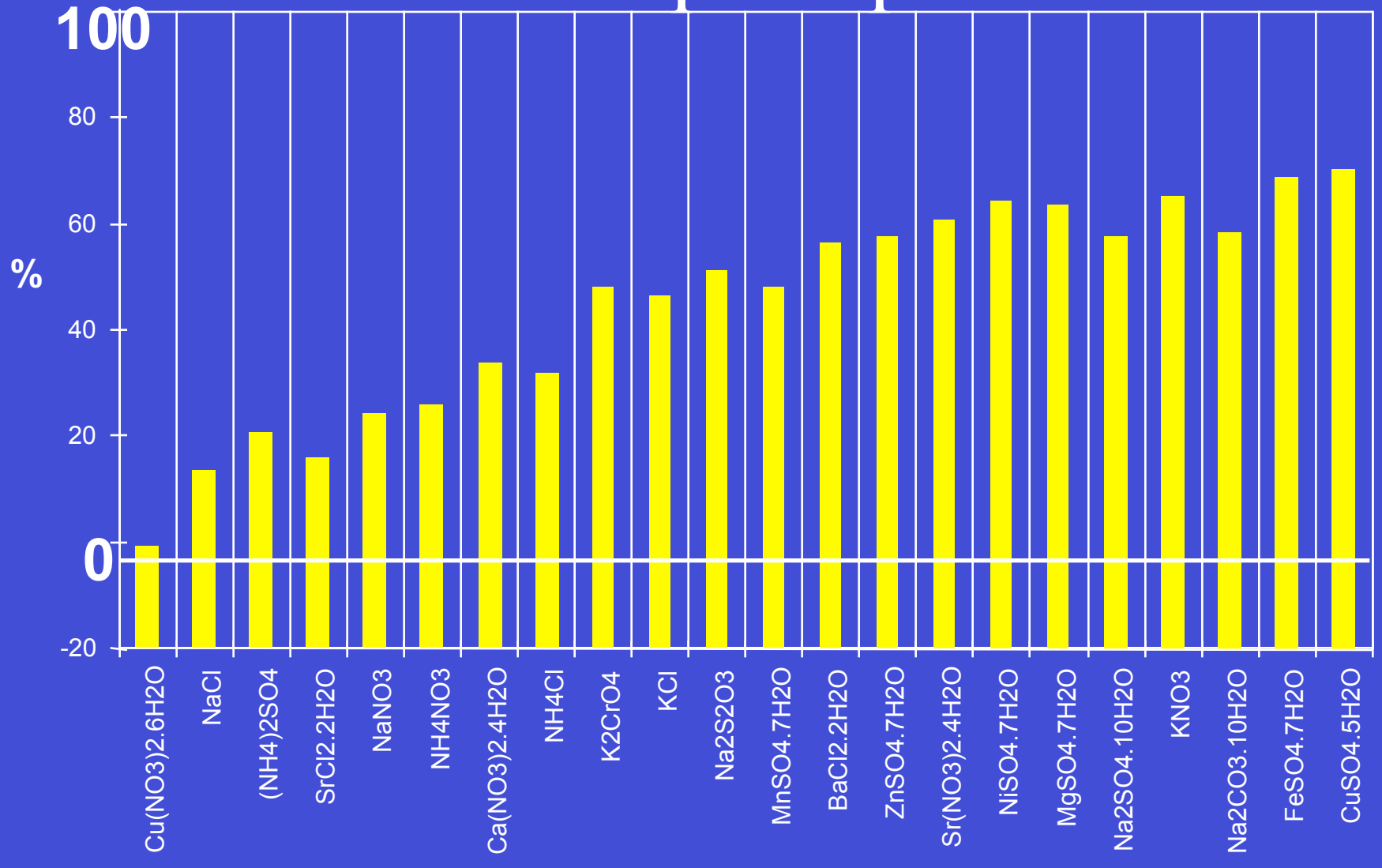
1000 L crystalliser
(Hans Evers)

Kosten & kwetsbaarheid

Energy efficiency of complete salt-water separation (equal basis comparison)



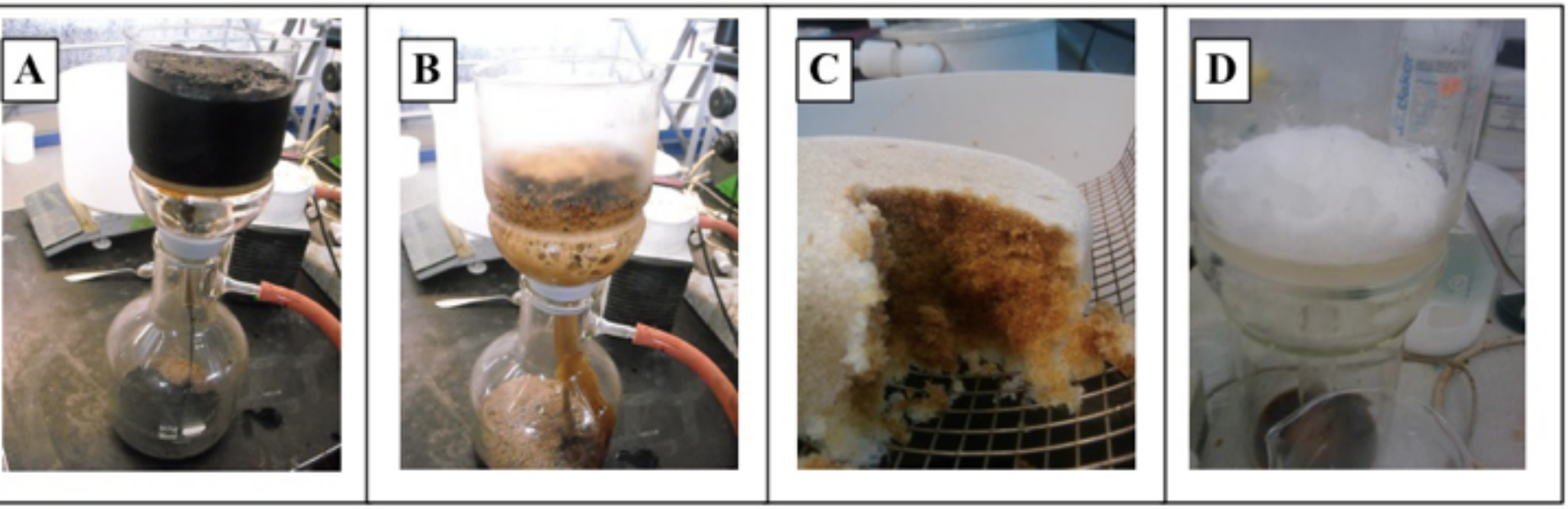
Energy savings EFC compared to 3-step evap.



Kwaliteit:

Purity of ice (from anion IX regenerate, with washing steps)

-



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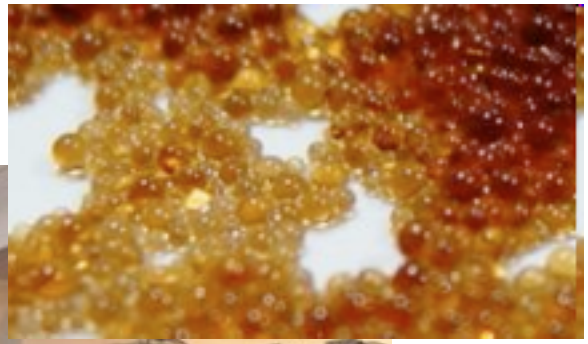
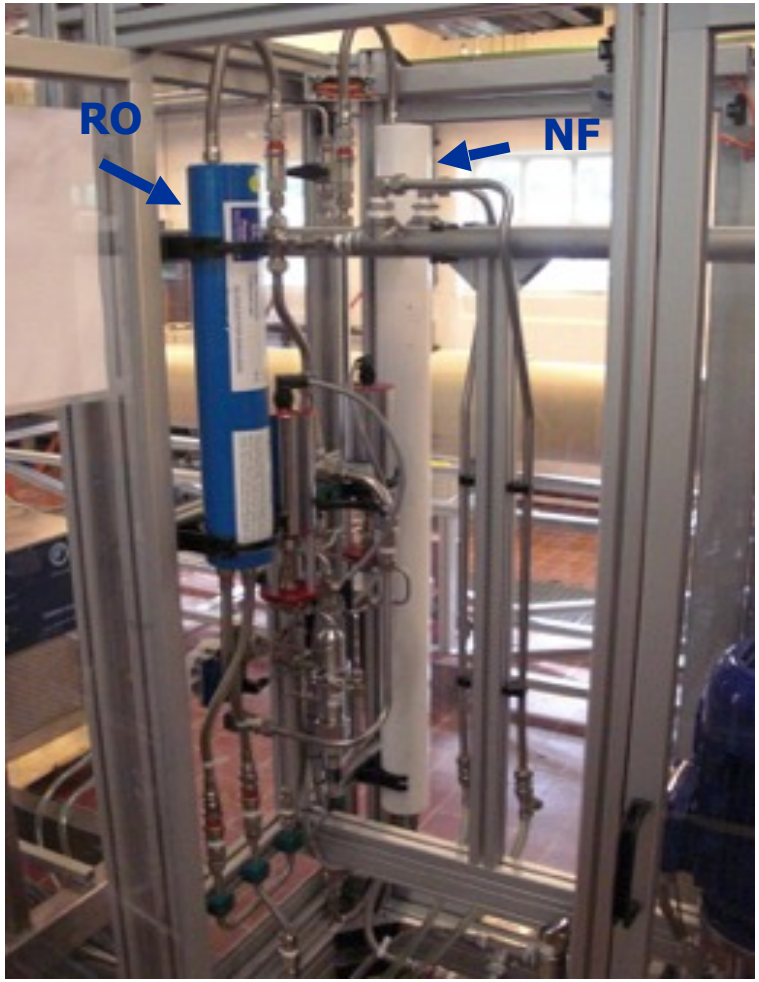
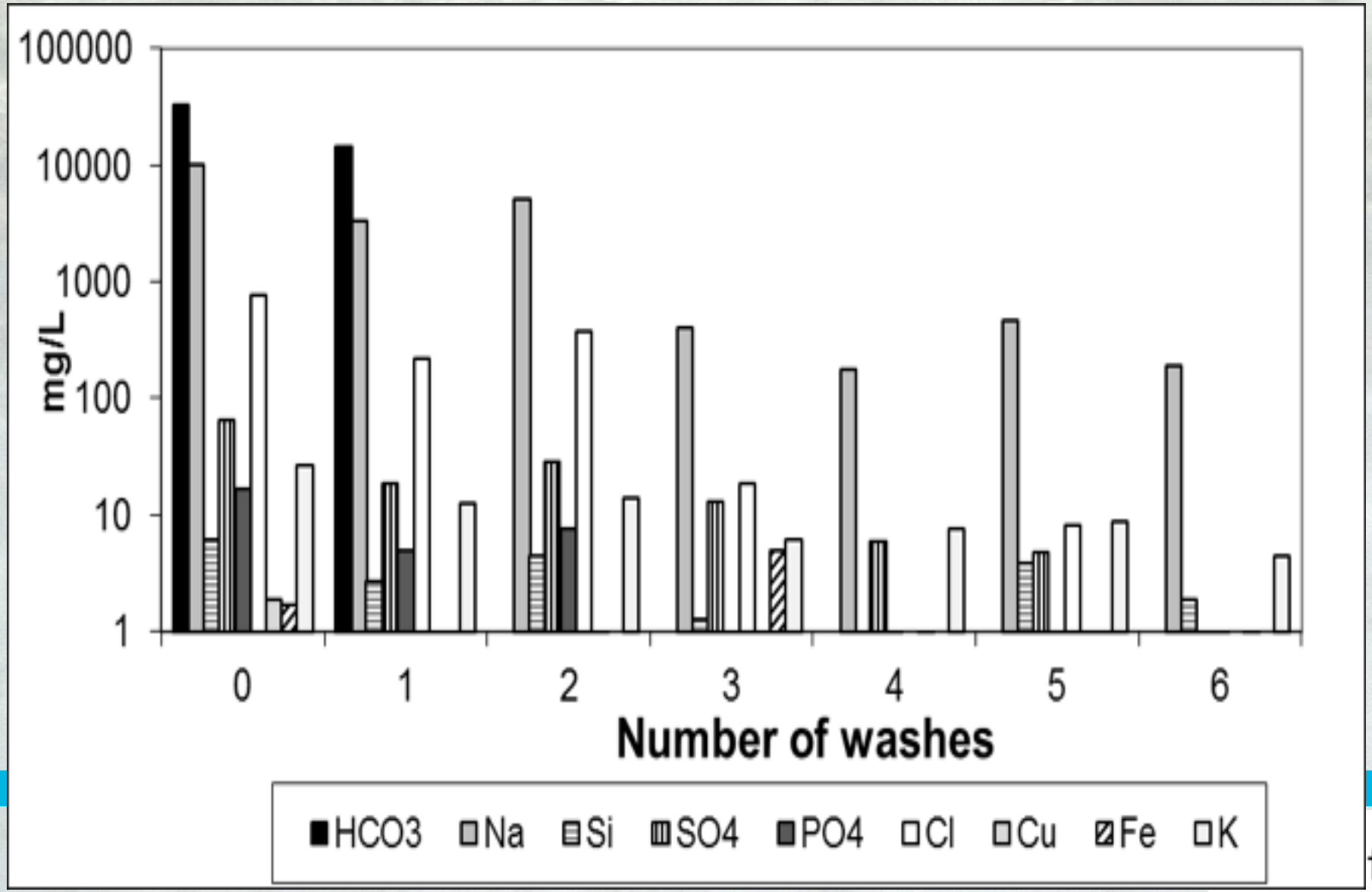
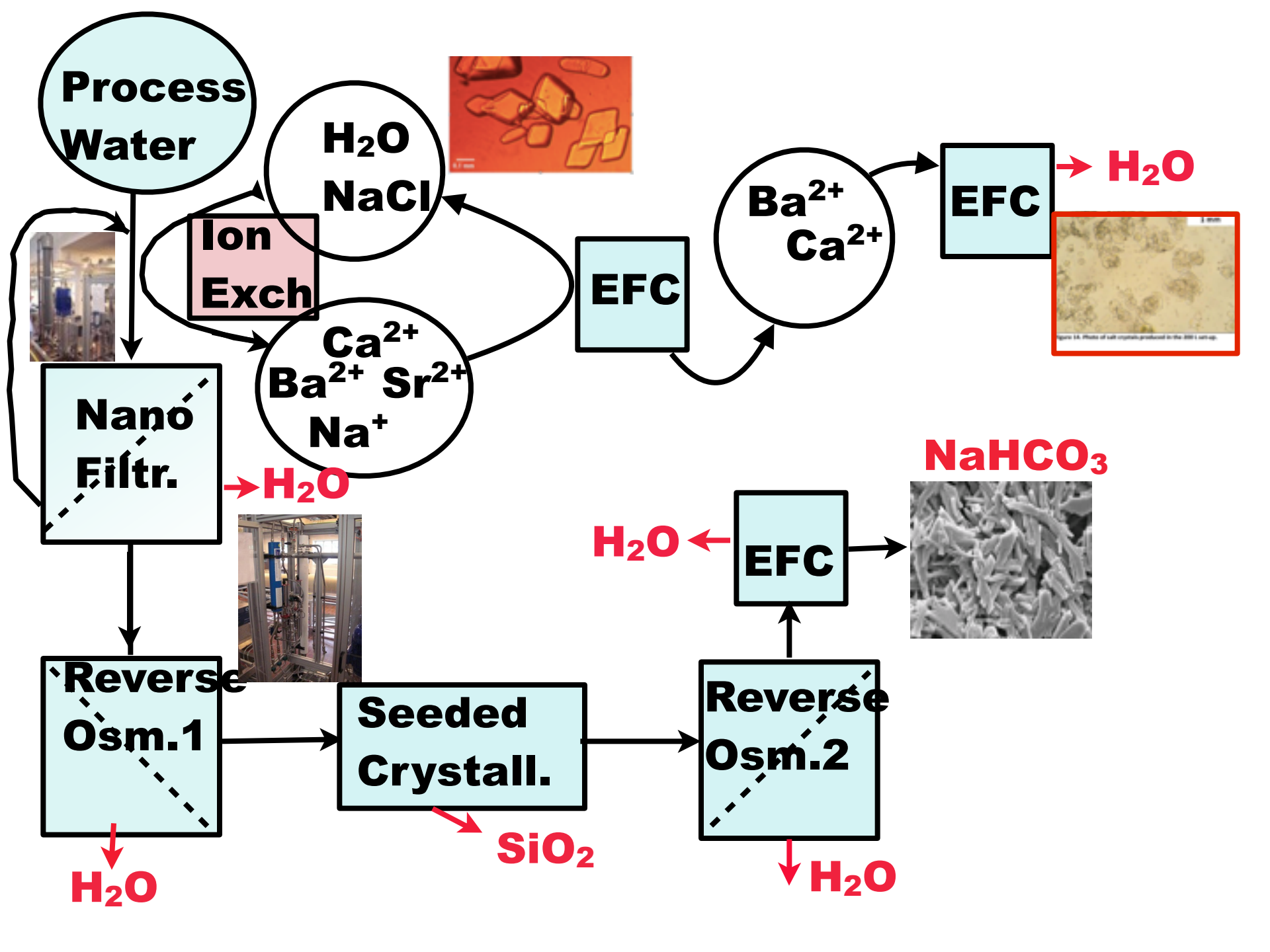
KWR PILOT PLANT
Ionenwisseling, Nanofiltratie, Rev. Osm.

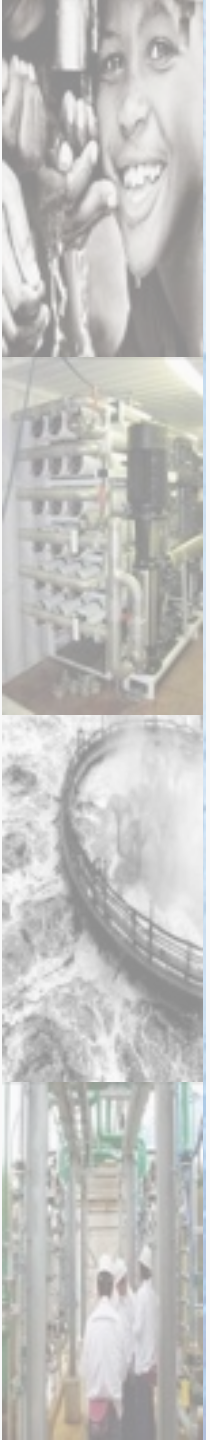




Kwaliteit: Resten in ijsslurrie




Process Water
H_2O NaCl
Ion Exch
Ca^{2+} Ba^{2+} Sr^{2+} Na^{+}
EFC
Ba^{2+} Ca^{2+}
EFC
H_2O
Nano Filtr.
H_2O
$NaHCO_3$
H_2O
EFC
Reverse Osm.1
Seeded Crystall.
Reverse Osm.2
SiO_2
H_2O
H_2O



Berekening Kosten

Nu 6.000.000 – 8.000.000 m³ brijn per jaar in Zuid-Holland

↓

Door Hogere Recovery: 2.000.000 – 3.000.000 m³ / jaar

↓

Stel kostprijs verlaging EFC naar € 8,00 / m³ (all–in)

↓

Kosten in Zuid-Holland € 16.000.000,- á 24.000.000,-

Circa 500 tuinders met brijninfiltratie

↓

Gemiddeld per tuinder € 32.000,- á € 48.000,- / jaar

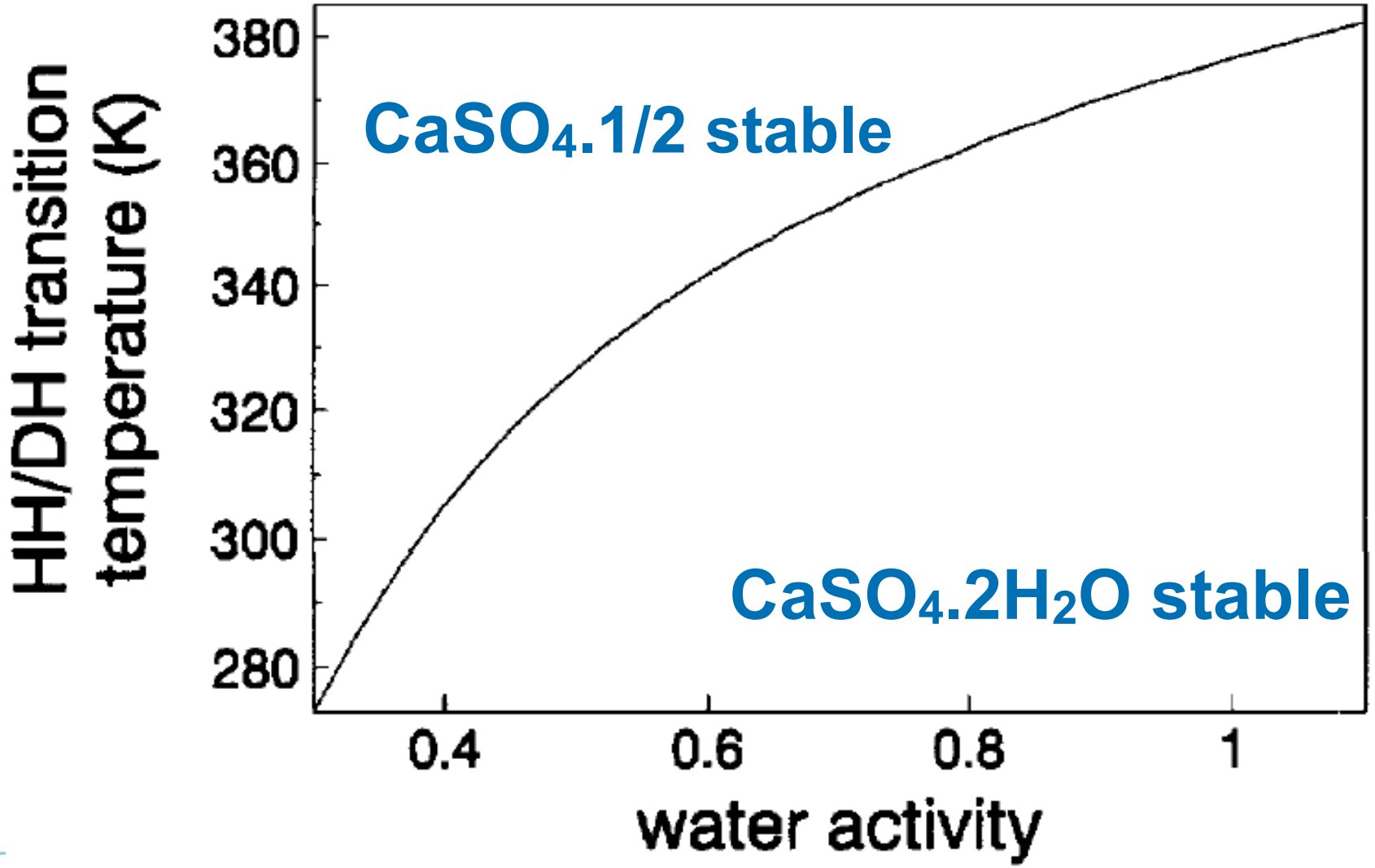
EFC kan in de toekomst in combinatie met andere technieken een alternatief zijn voor brijn infiltratie

Conclusies

- Betaalbare (Kosten) winning van zuiver water (Kwaliteit) zonder verspilling en met robuuste processen (Kwetsbaarheid) is mogelijk, daarbij kun je niet om Kristallisatie heen .

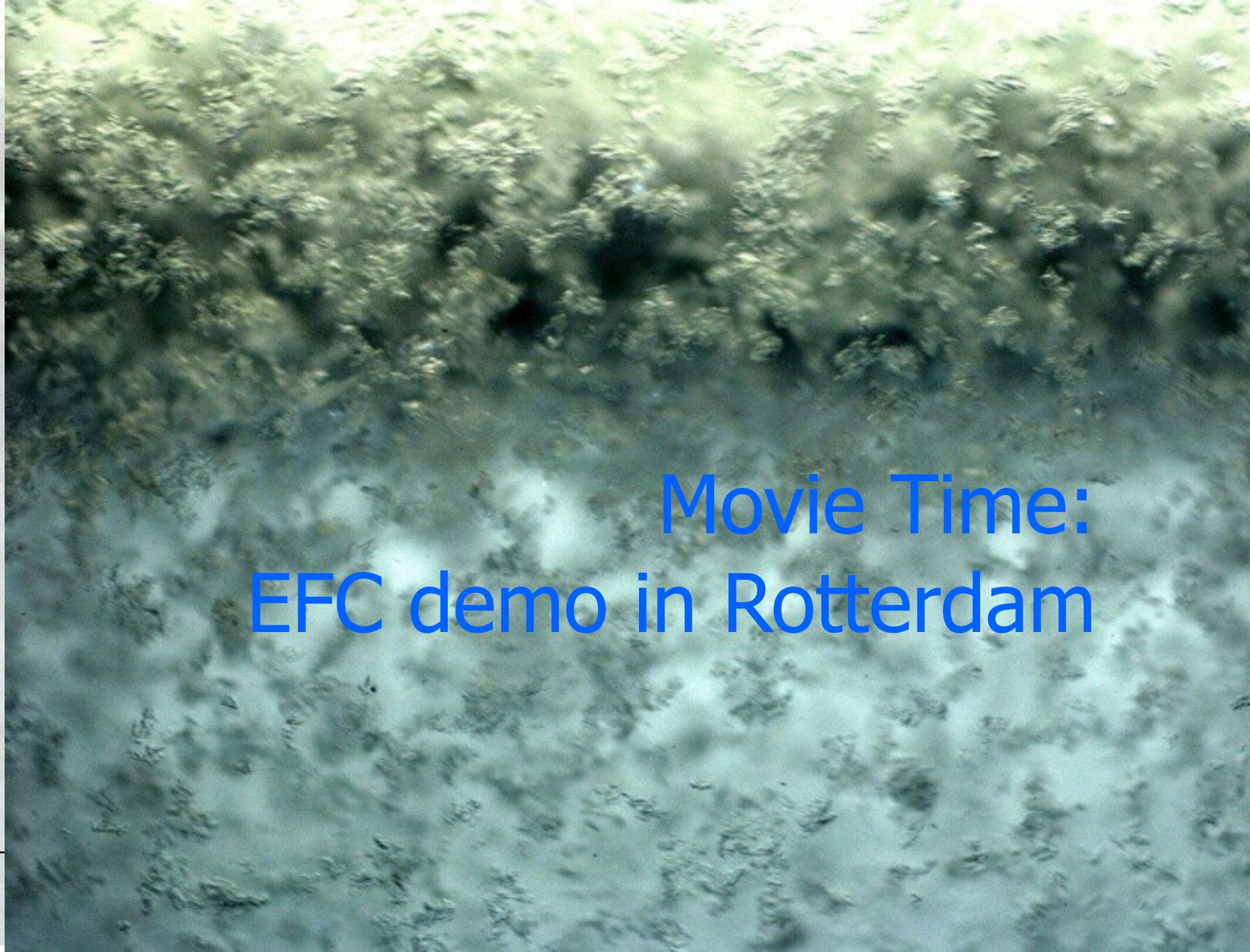
- Preventie van waterverbruik komt soms uit verrassende hoek

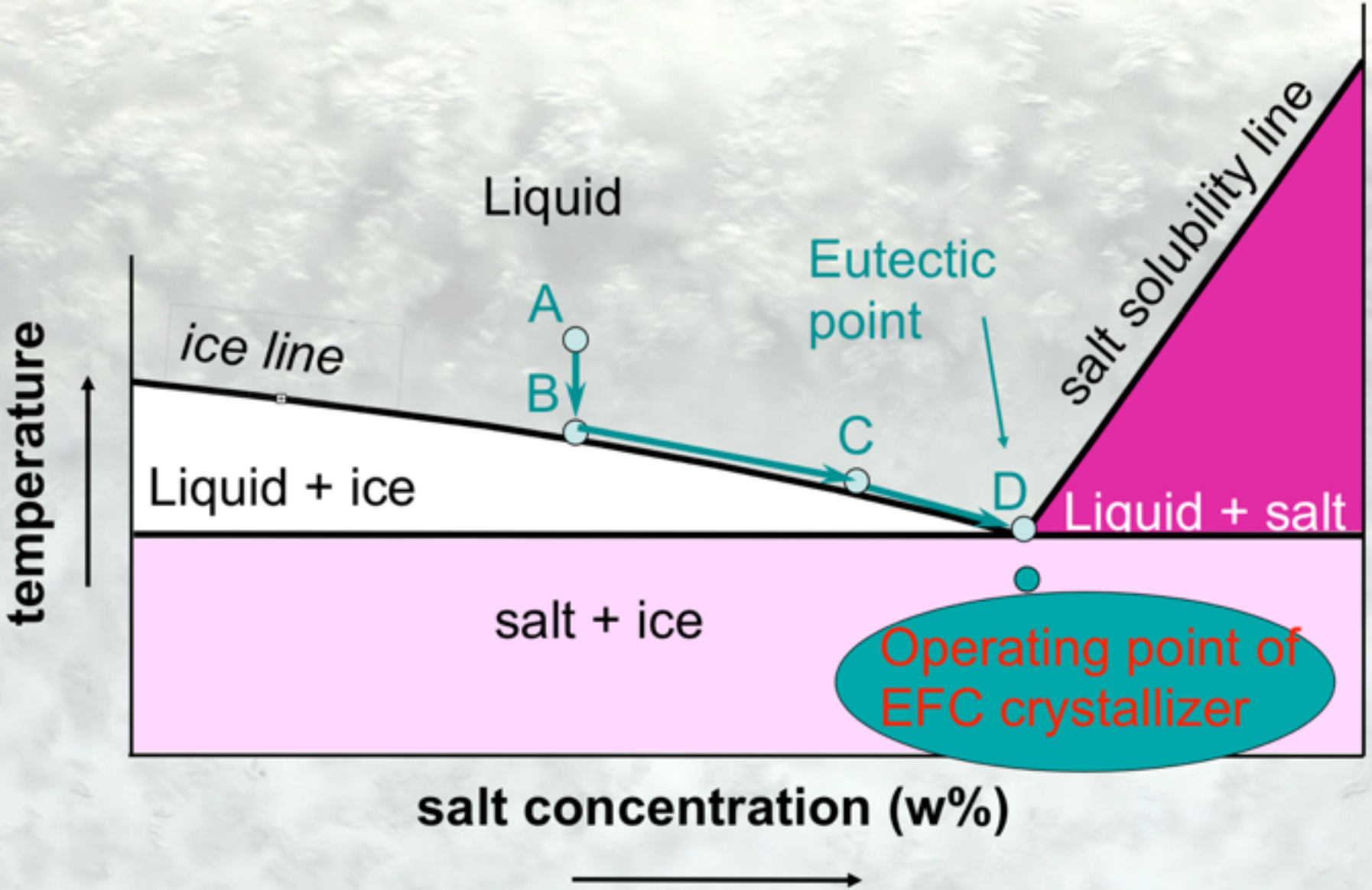
Water activity controls hydrated crystal phase transition temperature



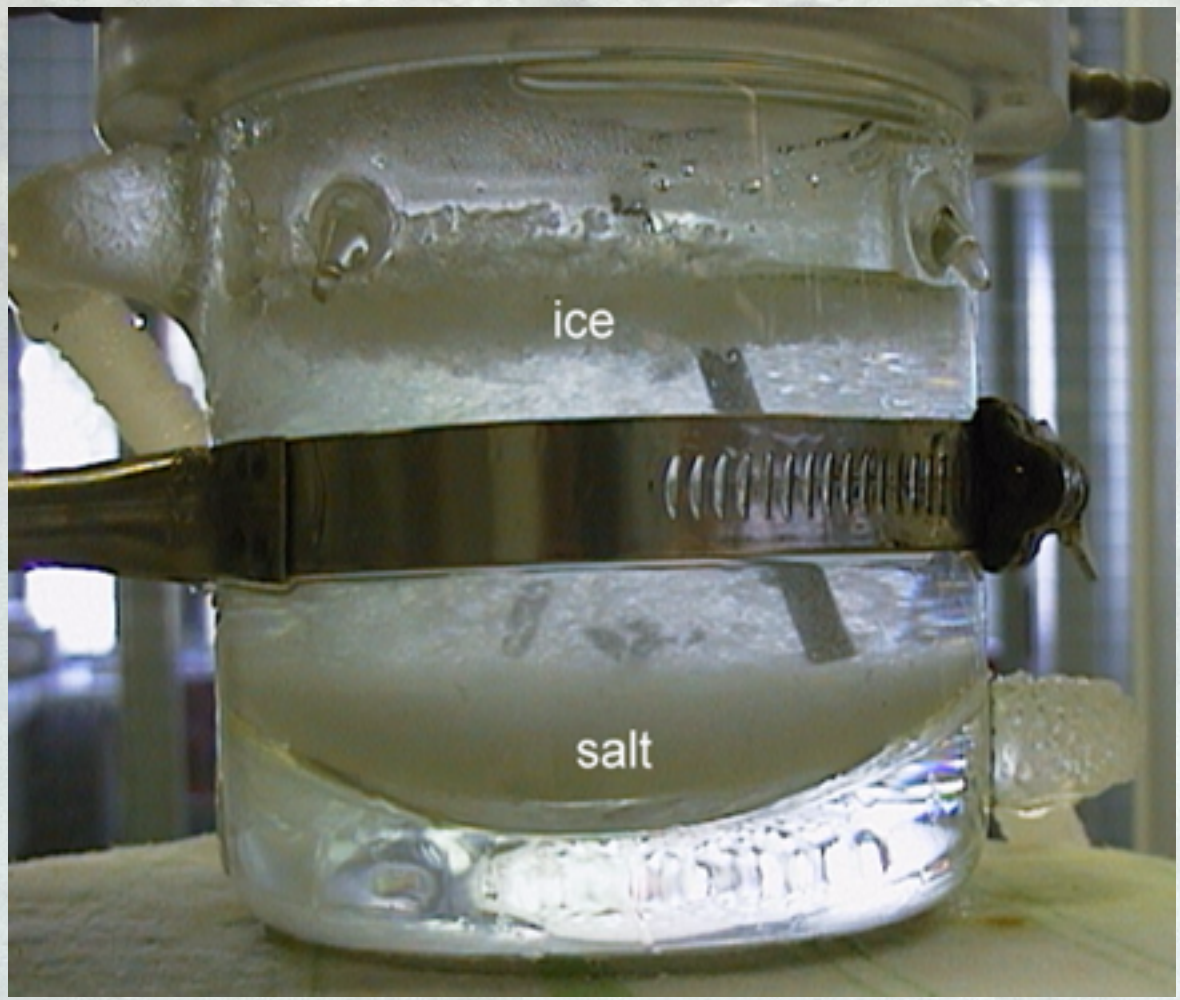
Current crystallisation topics [reference slide]

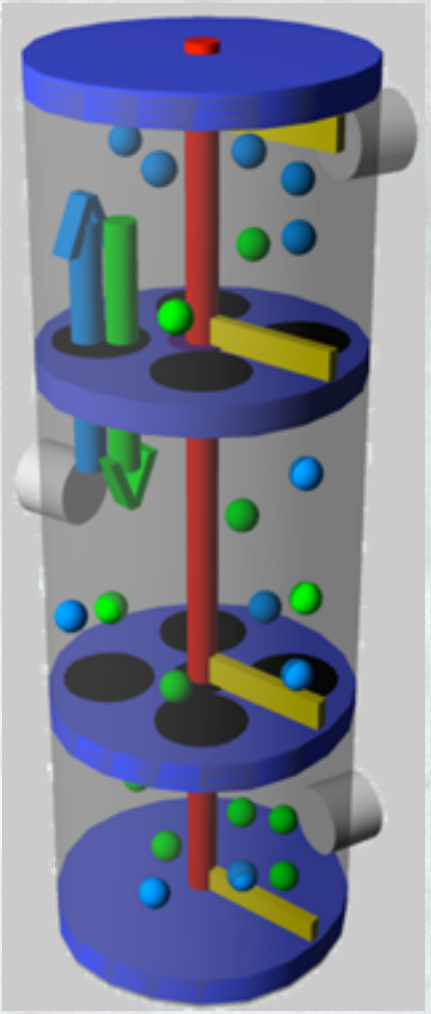
- Eutectic Freeze Crystallisation: scaling, nucleation, growth, recrystallisation, coupled heat&mass transfer (Onsager), gas hydrates, hydrodynamic design, cooling technology, mechanical design, impurities, fractionation
- Crystallisation from scCO2, ionic liquids,
- Calcium carbonate (scaling, for paper, antiscalants, ultrasound)
- Scaling sensor, scalant removal (Wetsus)
- Silica (anti-)scaling (Wetsus/KWR)
- Electrochemical precipitation (phosphate, iron oxides, carbonate) (Wetsus)
- Scale removal by hydrodynamic cavitation/high intensity waves
- Zero liquid discharge water treatment


Movie Time:
EFC demo in Rotterdam

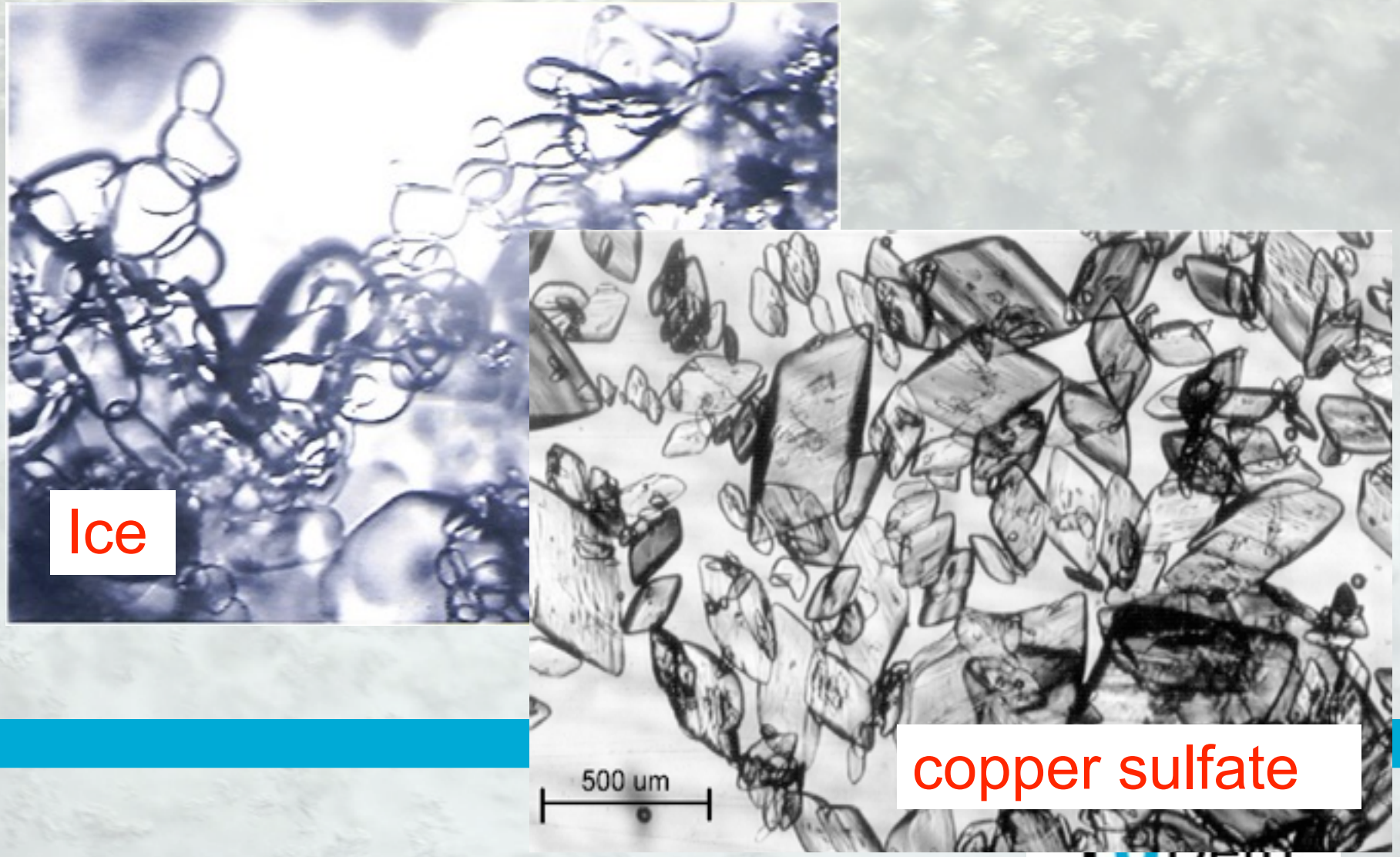

Liquid
Eutectic point
salt solubility line
A
B
C
D
ice line
temperature
Liquid + ice
Liquid + salt
salt + ice
Operating point of EFC crystallizer
salt concentration (w%)

EFC separation of ice and salt crystals

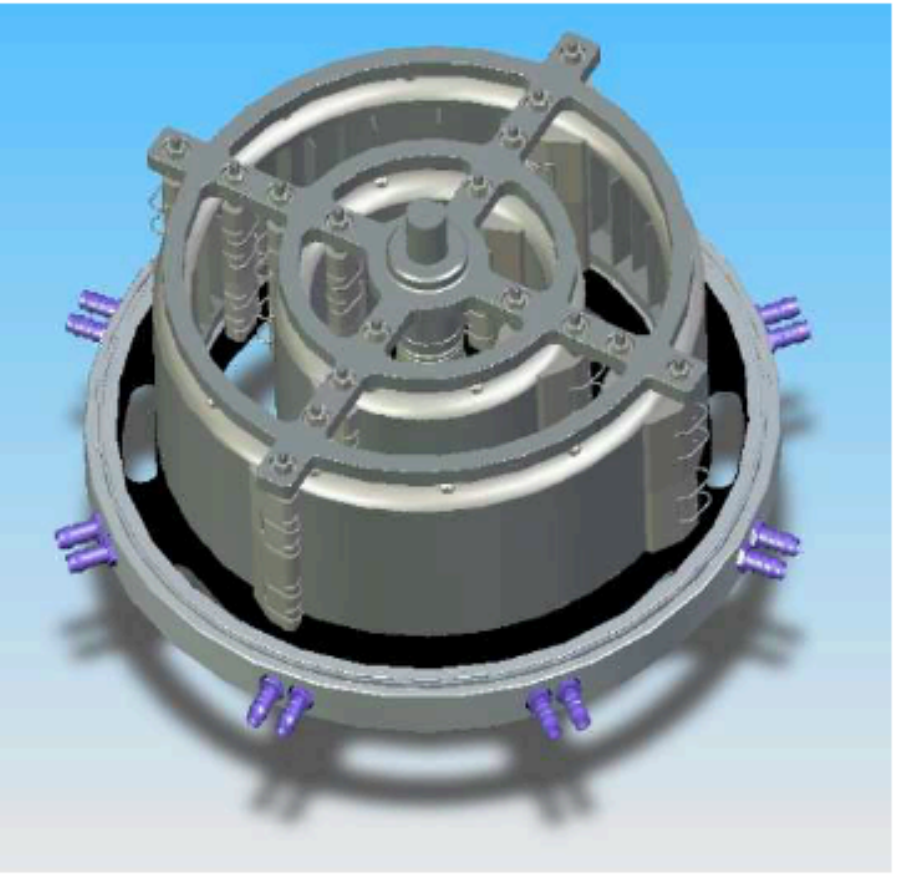


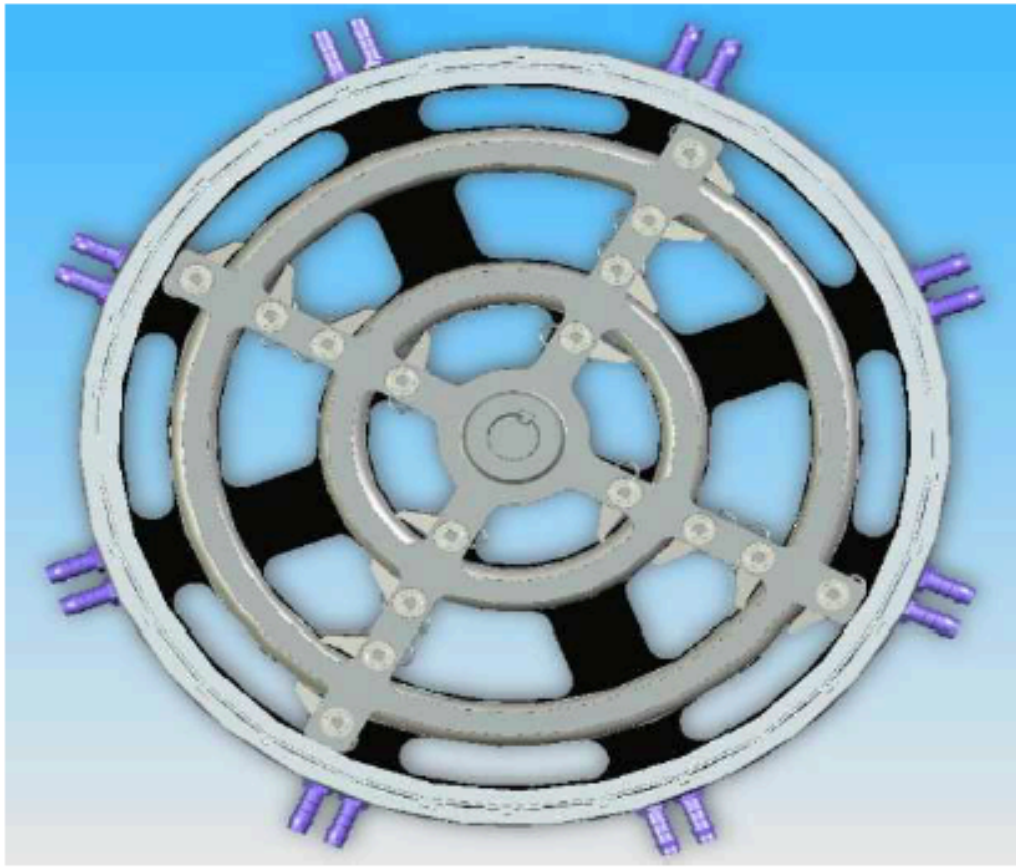


Simultaneous formation of ice and salt



Eutectic Freeze Crystalliser with KNO3 and ice



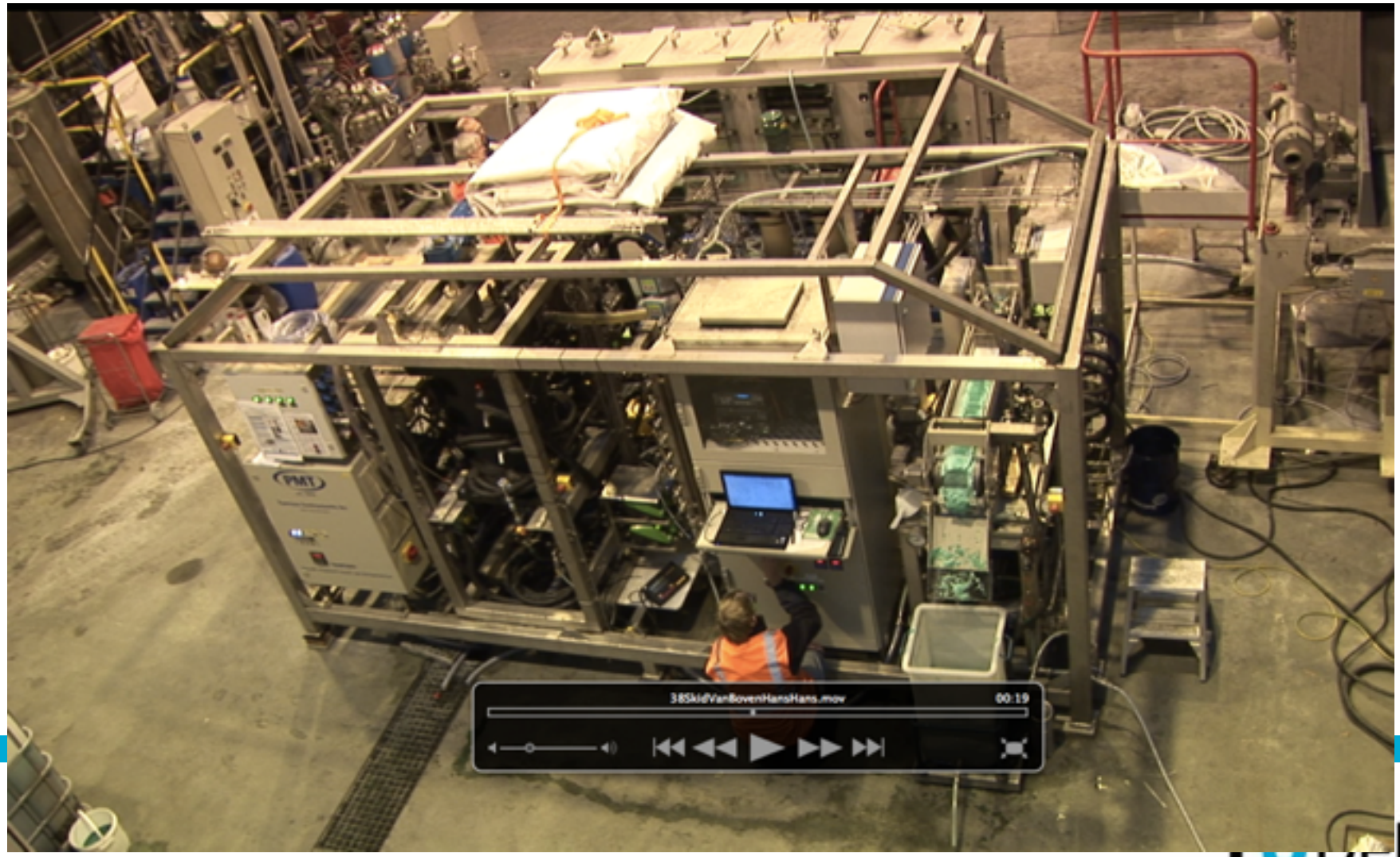


re 2. *Side and top view of the heat exchanger*

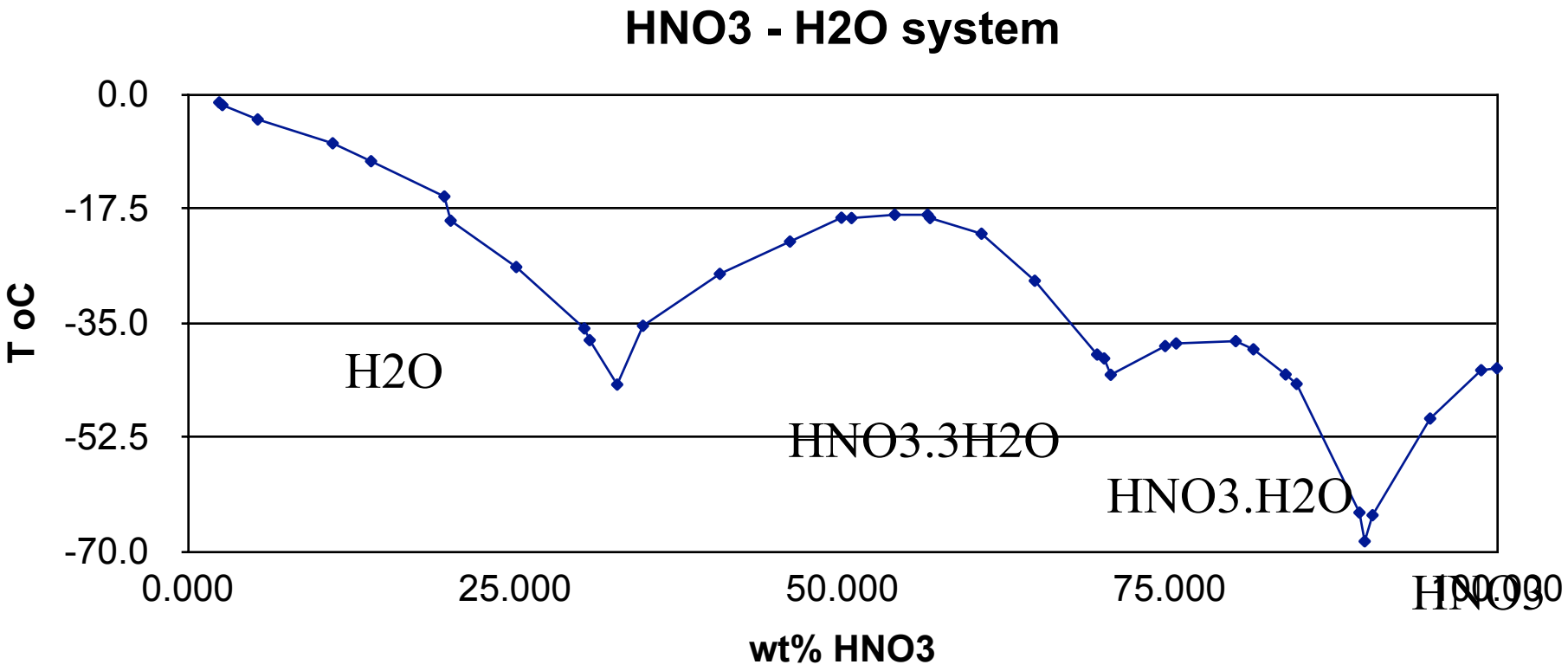
3rd industrial test run

Demonstration of EFC for Nickel Sulfate

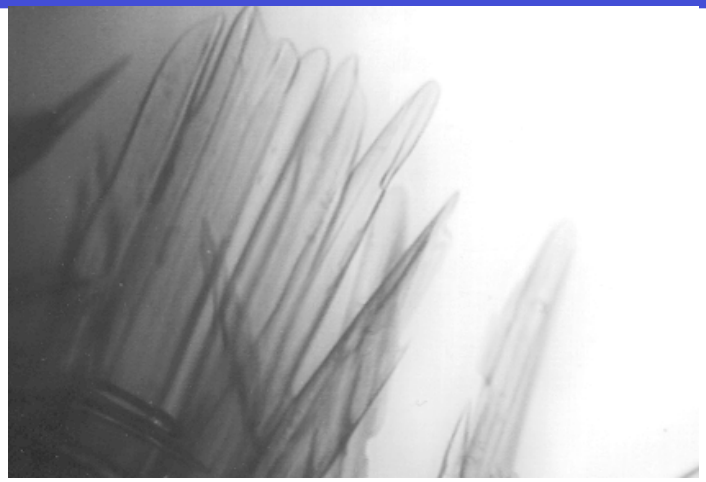
Umicore, Olen-Belgium, December 2010

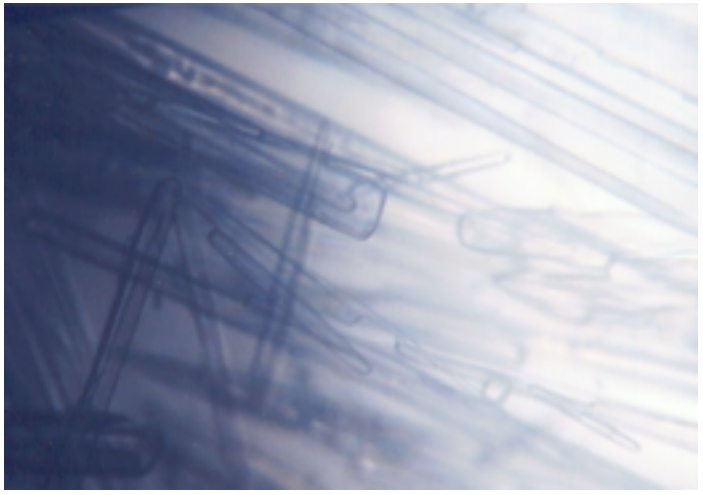


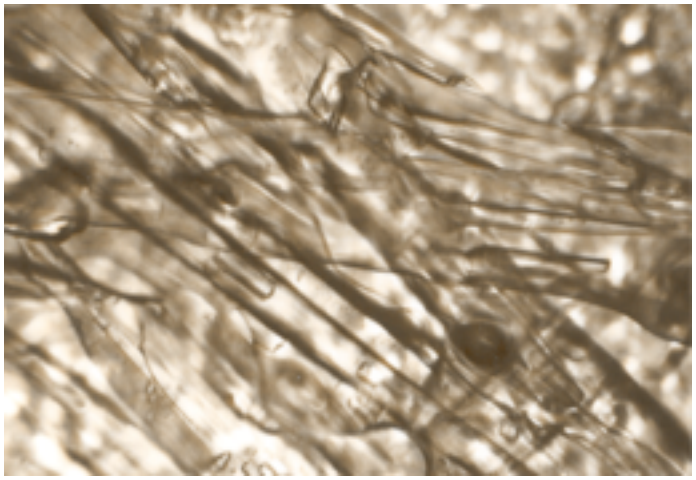
HNO3=H2O phases



HNO3.3H2O (Drummond)



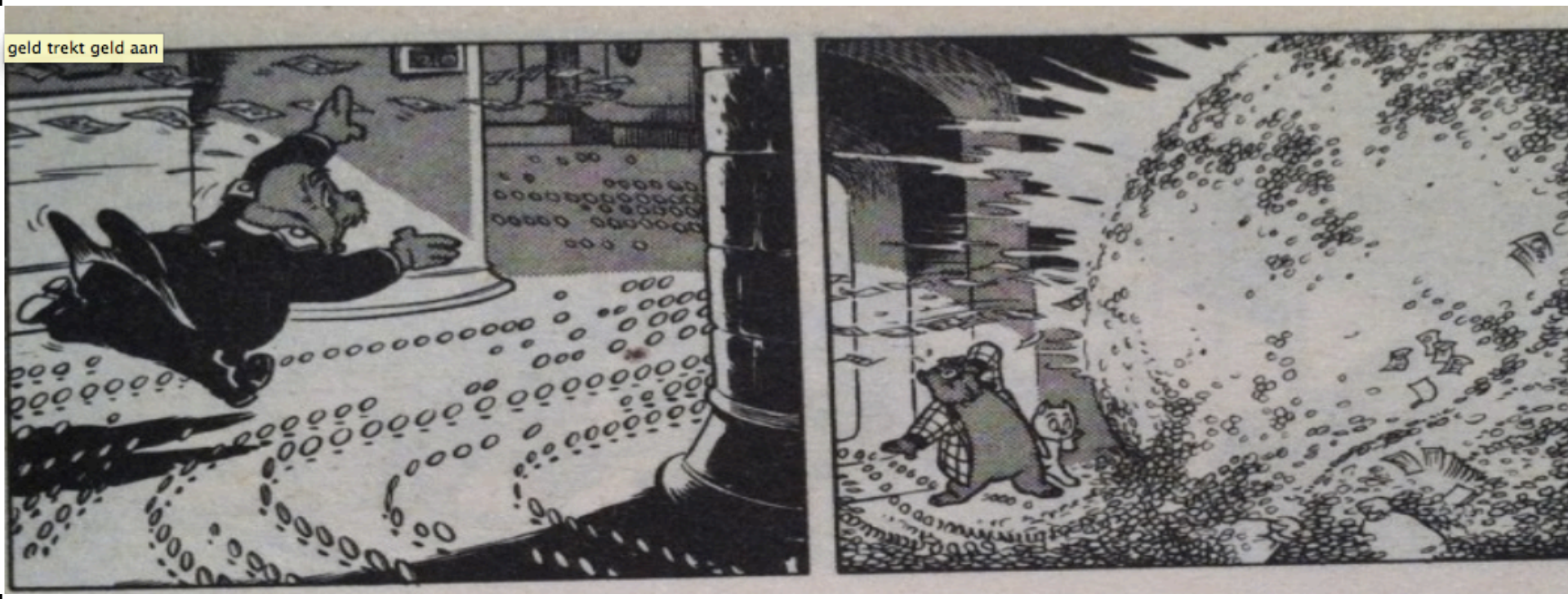





[End Movie]

EFC at Nedmag (MgSO4)

Ostwaldrijping



Insert logo university

EFC properties

Also for highly concentrated streams (complementory to Reverse Osmosis)

- 100% yield theoretically (contrary to cooling crystallisation)
- Very high purity of water
- Salt purity high due to inherent low supersaturation (compared to evaporation)
- Up to 90% lower energy costs compared to single stage evaporation, up to 50% compd to triple stage (20% estd for NaCl).

Zero Liquid Discharge Water Treatment (reference slide)

- Pretreatment
- UF/RO
- Removal of scalants by Ion Exchange, Liquid Liquid Extraction, Liquid Membrane Extraction etc.
- Removal of scalants in between RO stages by desupersaturation of scaling compounds with in-line crystalliser ($BaSO_4$, $CaCO_3$, SiO_2, $CaSO_4 \times H_2O$ etc)
- High Recovery RO
- Membrane Distillation
- Membrane Crystallisation
- EFC with in-line removal of scalants by crystalliser, winning of valuable trace elements
- EFC to treat IX regenerates